Digital Technology Use by Companies in the Furniture, Cabinet, Architectural Millwork, and Related Industries

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Abstract

Computer-aided manufacturing (CAM), in which computer-aided design (CAD) and computer numerically controlled (CNC) machining are integrated for the production of parts, became a viable option for the woodworking industry in the 1980s. To determine if using computer-based technologies in wood products design and manufacturing can streamline the many phases of production, a survey was conducted in 2006. Sixty-three percent of survey respondents indicated they use CAD. Even in the very small woodworking companies, CAD use was not uncommon, with 46 percent of them using CAD technology. Web sites and Web-based sales were being used by 41 percent of the survey respondents. Forty-one percent also used CNC machining. A much higher percentage of the large companies used CNC, considering that of all companies with 50 or more employees, 93 percent used CNC machining. CAM was the only other computer technology utilized by more than 20 percent of the respondents.

Streamlining the process of bringing new concepts and designs to production and market has been identified as a necessary component of a successful business strategy for US producers of value-added wood products (Schuler and Buehlmann 2003, Bumgardner et al. 2004). Of the factors identified as having the greatest potential for enhancing the competitiveness of secondary wood industries in the United States, more timely delivery to customers, better control over manufacturing, and closer interaction between marketing/design and manufacturing were rated to be the second, third, and fifth most important of 11 factors (Bumgardner et al. 2004). Each of these factors is closely associated with streamlining product design, development, and delivery. Shortened lead times and technology investment have been specifically and repeatedly cited as important competitive factors (Schuler and Buehlmann 2003, Bumgardner et al. 2004, Grushecky et al. 2006).

Digital technologies are available to assist in product design, manufacturing, and marketing across all manufacturing sectors. Many manufacturing enterprises have realized increased design and production efficiencies (i.e., streamlined production) after becoming proficient with digital technologies. Among the more familiar digital technologies are computer-aided design (CAD), computer numerically controlled manufacturing (CNC), machine monitoring and inventory management systems, and electronic commerce. Most wood products manufacturers are using one or more digital technologies to facilitate operations and communications. A compilation and analysis of best manufacturing practices used by the furniture industry indicated that several digital technologies were linked to top-performing companies: automatic storage and retrieval systems, implementation of a unique approach to CNC machines, and having a combination of CNC and conventional machines, online product tracking, and work traceability (Quesada-Pineda and Gazo 2007). There are some in the wood products industry who believe greater incorporation of digital technologies is critical to safeguarding the future of US companies competing for a sustainable share of value-added markets.

A survey of the use of advanced technology in manufacturing that was conducted by Statistics Canada for 2007 (Statistics Canada 2008) revealed that 86.4 percent of

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Canadian wood products manufacturing plants used at least one advanced technology and 60.5 percent reported using five or more advanced technologies. These adoption rates are high, but not compared with other manufacturing industry sectors—the overall average advanced technology adoption rate was 92.2 percent, with 68.9 percent of respondents indicating their plant used five or more advanced technologies (Statistics Canada 2008).

The US Census Bureau last conducted its Survey of Manufacturing Technology in 1993. These data were used in several studies that examined the relationships among technology adoption, firm demographics, and productivity. The results of these studies support the view that technologies that streamline the production process lead to improvements in a firm's competitive position. Higher growth rates and lower failure rates were experienced by manufacturing plants that adopted a larger number of advanced technologies (Doms et al. 1995), and higher labor productivity rates were associated with plants that used these technologies (McGuckin et al. 1996). The Survey of Manufacturing Technology data also indicated that newer technologies are more likely to be adopted by larger plants than by smaller plants (Dunne 1994). Each of these studies examined data across several manufacturing industries.

It appears that computer-aided manufacturing (CAM), in which CAD and CNC machining are integrated for the production of parts, became a viable option for the woodworking industry in the 1980s. Companies that bought their first CNC machines in the early 1980s were, for the most part, large manufacturers with sizeable capital investment budgets. In the late 1980s and early 1990s, more companies purchased their first CNC machines, but many companies were still regarding the technology from the sidelines and only a few companies moved toward an integrated CAM system. But, by the late 1990s, CNC machining technology, and to some extent CAM technology, was becoming more affordable and thus more widespread. For example, less substantial CNC routers could be acquired for as little as $5,000 while more robust industrial machines could be purchased for anywhere from $25,000 to $100,000 and up. Today, it appears that many mid-size manufacturers in the value-added wood products industry are using these technologies, and in some cases very small companies are now realizing that CNC and CAD technologies can be beneficial and financially feasible.

The degree of use of advanced digital technologies in the value-added wood products industry, types of technologies being used, differences in adoption rates among different sectors of the industry (i.e., firms producing different types of products), and the experiences and recommendations of adopters are meaningful and relevant as we endeavor to help the industry find its way through global competition and the economic downturn. We also are examining the rate of technology adoption by small manufacturing enterprises as well as large; in value-added wood products manufacturing, a significant percentage of firms have fewer than 20 employees. According to the results of the 2002 Census of Manufacturers (2007 results not yet released), the non-upholstered wood household furniture manufacturing industry (North American Industry Classification System 337122) consisted of 4,114 establishments of which 83 percent had fewer than 20 employees (US Department of Commerce, US Census Bureau 2004); this size demographic is common to most sectors of the industry. Finally, we seek to elucidate how the use of digital technologies might influence the competitive position of US manufacturers of value-added wood products.

Objectives

The objectives of this study were to (1) estimate the degree of use of digital technologies by various sectors of the value-added wood products industry, (2) determine if there is a relationship between technology utilization and firm size, and (3) determine expectations and benefits associated with different types of digital technologies as indicated by managers of value-added wood products operations.

Materials and Methods

A two-page survey of digital/computer use in wood products design and manufacturing was developed, reviewed, pilot tested, and mailed out during the late summer to early fall in 2006. The survey was mailed to 1,500 companies that subscribe to the magazine *Wood & Wood Products.* Of the 1,500 mailed surveys, 500 were sent to companies identified as (1) residential or contract furniture manufacturers, (2) residential or commercial cabinet manufacturers, and (3) architectural woodworking manufacturers. The survey population was randomly selected from a comprehensive listing of *Wood & Wood Products*' subscribers located in the northeastern and north-central United States (Maine to Minnesota and Missouri to West Virginia). The survey was mailed in an envelope that included a cover letter from Jeff Parsons of Beeken Parsons, Inc., a furniture producer in Vermont. Beeken Parsons, Inc., is highly regarded throughout New England as a leading manufacturer of high-end, custom casegoods and chairs. The survey mailing included a pre-addressed, postage-paid return envelope. Due to the limited financial resources available for this study, only one survey mailing was carried out. For this reason, early and late responders could not be distinguished, thus it was not feasible to conduct a nonresponse bias test.

The survey included several demographic questions to identify the type of product produced by the respondent's company, years in operation, location, workforce size and 5-year size trend, and 5-year sales volume and revenue trends (more than doubled, increased but not doubled, about the same, lower). Information was collected on current digital technology use and anticipated technology adoption. This was followed by a set of questions focused on CNC technology use and impacts. A 5-point Likert scale was used to elicit feedback on a series of statements related to CNC implementation. Questions on the impacts of CAD technology followed (again, a 5-point Likert scale). Finally, three open-ended questions were posed to elicit free-form feedback on digital technology use within the value-added wood products industry.

Coding and analyses

Survey responses were entered into a spreadsheet then imported into SAS for statistical analysis. Proportional response rates were calculated for each of the demographic variables. Statistical tests were evaluated using a significance level of 0.10 ($\alpha = 0.10$); this significance level is used to allow trends to be identified in market surveys

(Bumgardner et al. 2004, Luppold and Bumgardner 2007). Chi-square tests of independence were conducted to ascertain if our two independent variables of interest—product type manufactured and firm size—were independently distributed relative to the regional location of the responding firms.

Responding firm locations were categorized into one of four regions: New England, Mid-Atlantic, Lake States, or East Central. Responding firm size was categorized into one of three categories based on total number of employees at a given operating facility: large firms ($\geq$50 employees), medium firms (15 to 49 employees), and small firms (<15 employees).

The null hypothesis (H_0) for the 4×4 chi-square test of product type and firm location was the following: the proportions of companies manufacturing furniture, cabinets, architectural millwork, or a combination of the above that responded to the survey were the same for the four geographic regions. The null hypothesis (H_0) for the 3×4 chi-square test of firm size and firm location was the following: the proportions of small, medium, and large companies that responded to the survey were the same for the four geographic regions.

The chi-square test also was used to examine whether the 5-year revenue change responses (more than doubled, increased but not doubled, about the same, smaller) were independent of firm size (small, medium, large). The final chi-square test of independence that was conducted was between the variables 5-year revenue change and number of technologies adopted.

Overall mean response values were calculated for several questions including the two series of Likert scale–based questions concerning CNC and CAD technologies. To address Objectives 1 and 2 simultaneously, a factorial analysis of variance (ANOVA) using the GLM procedure was conducted. The number of types of digital technologies adopted by each responding firm was the dependent variable in this model and the independent variables were product type (furniture, cabinets, architectural woodworking, multiple products) and firm size (small, medium, large). Separation of means was performed using the Tukey studentized range test and a significance level (α) of 0.10. To determine if type of product produced and size influenced the attitudes of respondents about CNC and CAD technologies, two MANOVAs were performed (α = 0.10) on the Likert scale–based responses.

Results and Discussion

The response rate for this mail survey was 11.6 percent—174 usable surveys were returned from the 1,500 that were sent out. The demographic profile of the respondents, as indicated by their answers to the first nine questions of the survey, is shown by the following:

- Value-added **sectors** of responding firms: (1) furniture, 20 percent; (2) cabinets, 17 percent; (3) architectural woodworking, 15 percent; (4) multiple sectors, 45 percent; and (5) other sectors, 3 percent (172 responses to this question).
- **Firm size**, based on total number of employees: 61 percent had fewer than 15 employees (small firms), 22 percent had between 15 and 49 employees (medium), and 17 percent had 50 or more employees (large firms) (165 responses).
- **Year** production operation started: before 1950, 6 percent; 1950 to 1969, 10 percent; 1970 to 1989, 51 percent; and since 1990, 33 percent (168 responses).
- **Region** where operation was located: New England (New York, Massachusetts, Rhode Island, Connecticut, Maine, New Hampshire, Vermont), 31 percent; Lake States (Michigan, Wisconsin, Minnesota, Ohio), 26 percent; Midwest (Indiana, Illinois, Iowa, Kentucky, Missouri), 22 percent; and Mid-Atlantic (Virginia, West Virginia, Maryland, New Jersey, Pennsylvania, Delaware), 21 percent (174 responses).
- **Size of workforce in 2006 compared with 2001**: larger, 25 percent; the same, 59 percent; and smaller, 16 percent (173 responses).
- **Annual production volume** in 2006 compared with 2001: more than doubled, 11 percent; increased but not doubled, 42 percent; the same, 33 percent; and lower, 14 percent (172 responses).
- **Annual revenues** in 2006 compared with 2001: more than doubled, 8 percent; increased but not doubled, 52 percent; the same, 26 percent; and lower, 14 percent (172 responses).

Digital technology adoption rates

Of the eight types of advanced digital technologies listed on the survey, the mean number of types of technologies used by the 174 responding firms in 2006 was 2.2. Two companies indicated they used all eight technologies while 40 of the responding firms (23%) were not using any of the technologies. Overall, the three types of digital technologies that are most widely used are CAD (63% of respondents), CNC (41%), and Web sites (41%; Fig. 1). Considering only the 134 firms that have adopted digital technologies, these companies use, on average, 2.8 different types of technologies. Eighty-two percent of the companies that use digital technologies use CAD.

Of the 40 responding firms that did not use any of the listed digital technologies in 2006, five indicated they anticipated adopting CAD technology in the next 3 years,

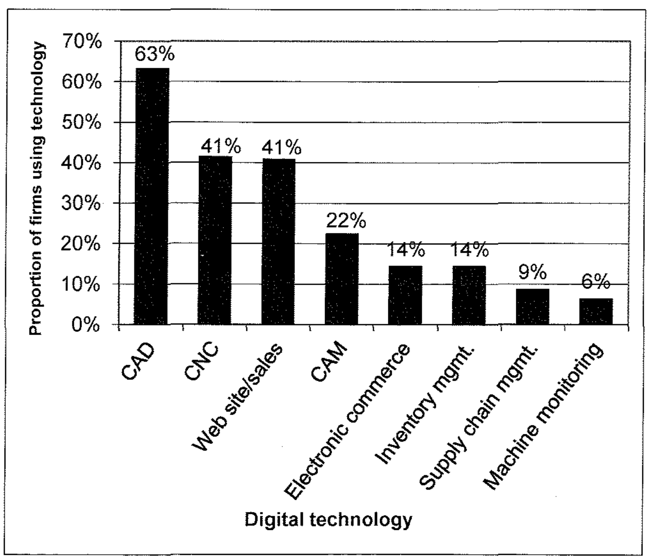

Figure 1.—Proportion of value-added wood products firms in the northeastern and north-central United States using different types of digital technologies (in percent).

Table 1.—Types of digital technologies used by companies that have adopted one, two, three, or four types of technologies in their wood products manufacturing operations.

Type of technology	Proportion (%) of firms using different types of technology			
	1 type (n = 34 firms)	2 types (n = 37 firms)	3 types (n = 24 firms)	4 types (n = 19 firms)
CAD	56	78	92	100
CNC	3	43	65	89
Web	25	46	50	74
CAM	3	5	31	53
Supply chain management	0	3	12	11
Electronic communications	6	8	19	47
Inventory management	0	8	19	16
Machine monitoring	3	3	4	5
Other	3	5	8	5

three indicated they planned to develop a Web site, and one was developing plans to integrate a CNC router into their operations. Analysis of the types of technologies in use by companies that are using only one digital technology shows a similar leaning toward CAD with 56 percent of these firms having adopted CAD. The relative order of adoption of the different types of technology is apparent in Table 1—as firms move from no digital technologies to first one, then two, etc., they reliably adopt CAD, CNC, and Web systems first.

Factors affecting the rate of digital technology adoption

Factorial ANOVA results indicated that the model was significant, with the overall F test returning a P value of <0.0001:

$$N_{ijk} = \mu + (P)_i + (S)_j + (P \times S)_{ij} + \varepsilon_{ijk}$$

where

N = number of types of technologies adopted

P = product type, and

S = firm size (class variable based on number of employees).

Examination of the influence of the two classification variables, product type and firm size, and the interaction of the two variables found that the interaction term was not significant. The model was revised to include only the main effects. Again, the full model returned a P value of <0.0001, but the main effects analysis indicated that product type was not significant ($P = 0.7944$). The model was further revised to include only size. The R^2 value for the final version of the model was 0.38, indicating the 38 percent of the variation of the dependent variable, number of technologies adopted, could be attributed to variation based on firm size.

The Tukey separation of means test (see Table 2) indicated that the number of technologies adopted by firms was different for all three size classes. Firms having 50 or more employees reported having adopted, on average, 4.3 types of digital technologies in their operations. Mid-size firms (15 to 49 employees) reported adopting an average of 3.0 types of technology. Small firms (<15 employees) had adopted 1.3 types of digital technologies in their plants.

The results of chi-square analyses to determine if the rates of adoption of the various types of technologies included in the survey were different for small, medium, and large firms (based on numbers of employees) indicated significance. The two types of digital technologies that were most broadly adopted by survey respondents, CAD and CNC, were used by large firms and medium-sized firms significantly more frequently ($P < 0.0001$) than they were by small firms (Fig. 2). In fact, all eight of the listed technologies showed significantly different results for rates of adoption based on firm size (the Fisher's exact test form of the chi-square analysis was used due to low sample sizes in some cells).

Objective 1, to estimate the degree of use of digital technologies by various sectors of the value-added wood products industry and Objective 2, to determine if there is a relationship between technology utilization and firm size, were both fulfilled in this statistical analysis. None of the variation in the number of technologies adopted between firms was found to be associated with whether the responding firm manufactured furniture, cabinets, architectural woodwork, or a combination of these products. The overall mean number of technologies adopted for all product sectors was 2.19. In contrast, 38 percent of the variation in the number of technologies adopted between firms was found to be associated with firm size (based on number of employees).

Digital technologies and firm revenue

Results of the analysis to determine if there was a relationship between the number of types of digital technologies used by responding firms and the change in revenue performance for each firm indicated a relationship was present (chi-square test, $P = 0.09$). Firms that experienced revenue growth during the period 2001 through 2006 had adopted either a few (one to three) or several (four or more) types of digital technologies, while firms that had not adopted any digital technologies were more likely to have experienced either stagnant or declining revenue (Table 3). It cannot be ascertained that this is a cause and

Table 2.—Results of the Tukey HSD separation of means test for number of types of technologies adopted for different levels of the variable firm size.

Classification variable	Levels compared	Difference between means[a]
Firm size	Large to medium	1.29
	Large to small	2.97
	Medium to small	1.67

[a] All values are significant at the <0.10 level.

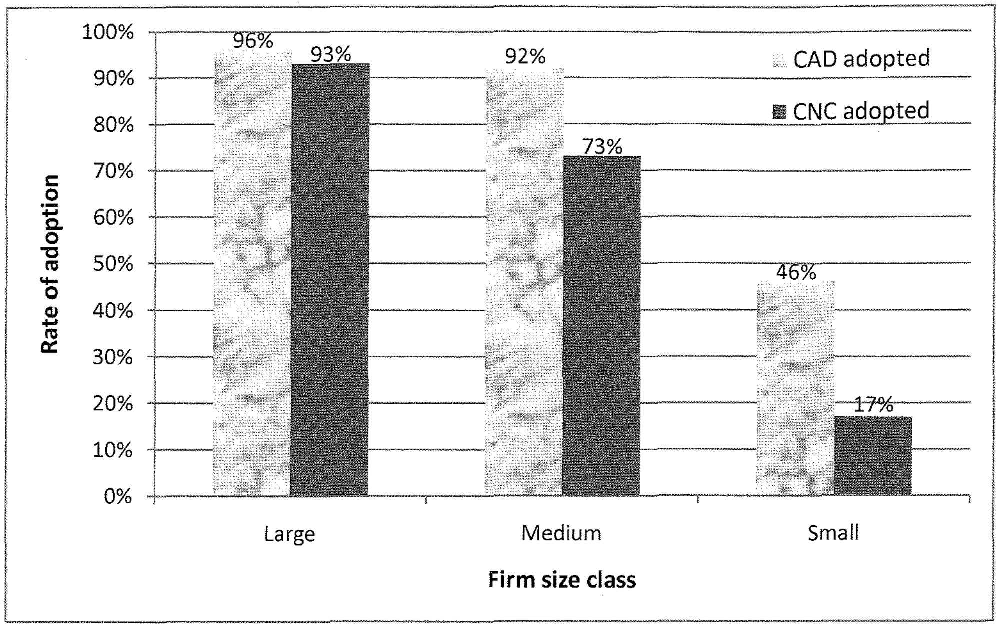

Figure 2.—Number of responding firms that have adopted CAD and CNC technologies by firm size.

effect relationship—i.e., it is not necessarily appropriate to draw the conclusion that companies that are more committed to digital technologies earn higher revenues. It may be that the greater cash flow associated with greater revenues affords companies the opportunity to purchase digital technologies. It is likely a combination of both of these interpretations along with other factors that account for this relationship.

One of the other factors that could influence the relationship between revenue and level of adoption is firm size. As we previously substantiated that large firms adopted more technologies than the responding medium-sized firms who in turn adopted more technologies than the small firms (Table 2), the influence of firm size on revenue change is germane to this discussion. Results of the analysis to determine if there was a relationship between the size of responding firms and the 5-year change in revenue performance for each firm did not indicate the presence of a relationship (chi-square test, $P = 0.42$). Thus, while firm size affects level of technology adoption it is not related to 5-year revenue change.

Use of digital technologies in marketing and sales

Since several types of digital technologies can be integrated into marketing and sales efforts, we investigated the means used by responding firms to sell their wood products to search for possible relationships between technology use and sales platforms. The sales platform with the most obvious linkage to digital technologies was Web-based sales. Overall, Web-based sales comprised only 1.06 percent of total sales in 2006 for the 169 firms that provided this information. For the 25 companies that indicated they had adopted electronic commerce (one of the listed digital technologies), Web-based sales comprised 3.09 percent of sales. For the 71 companies that indicated they had adopted Web technologies, Web-based sales comprised 2.22 percent of sales. So, while Web-based sales for companies using these two technologies were higher than for other companies that responded to this survey, they were not as high as might be expected. It appears that companies that were involved in e-commerce were doing more buying online than selling in 2006. Similarly, the companies that had a Web presence may have been using the Web to support marketing efforts, but many had not gone the final step to sell their products online.

CNC adoption

Of the 71 responding companies that used CNC machines in their wood products manufacturing operations, 63 percent were using one or more CNC routers (Fig. 3). Panel saws and point-to-point machines were each being used by 34 percent of these companies while 32 percent used CNC machining centers (Fig. 3). About half of the companies using CNC equipment used only one type of CNC machine. Twenty-six percent of the companies that used CNC machines were using three or more types of CNC machinery, and in many cases, multiple machines of each type.

The mean response to the question, "In what year did you purchase your first CNC machine?" was 1996. As expected,

Table 3.—Frequency results used in chi-square test for independence for level of technology adoption versus 5-year revenue change.

	Level of technology adoption[a]		
5-Year revenue change	None, no. (%)	Few (1–3), no. (%)	Several (≥4), no. (%)
More than doubled	0 (0.0)	9 (9.5)	5 (13.2)
Increased but not doubled	16 (41.0)	54 (56.8)	19 (50.0)
Same	15 (38.5)	21 (22.1)	8 (21.0)
Lower	8 (20.5)	11 (11.6)	6 (15.8)
Total	39 (100)	95 (100)	38 (100)

[a] The level of technology adoption categories was formulated to allow for a sufficient number of observations in each cell to conduct chi-square analysis; $P = 0.09$ (χ^2 test).

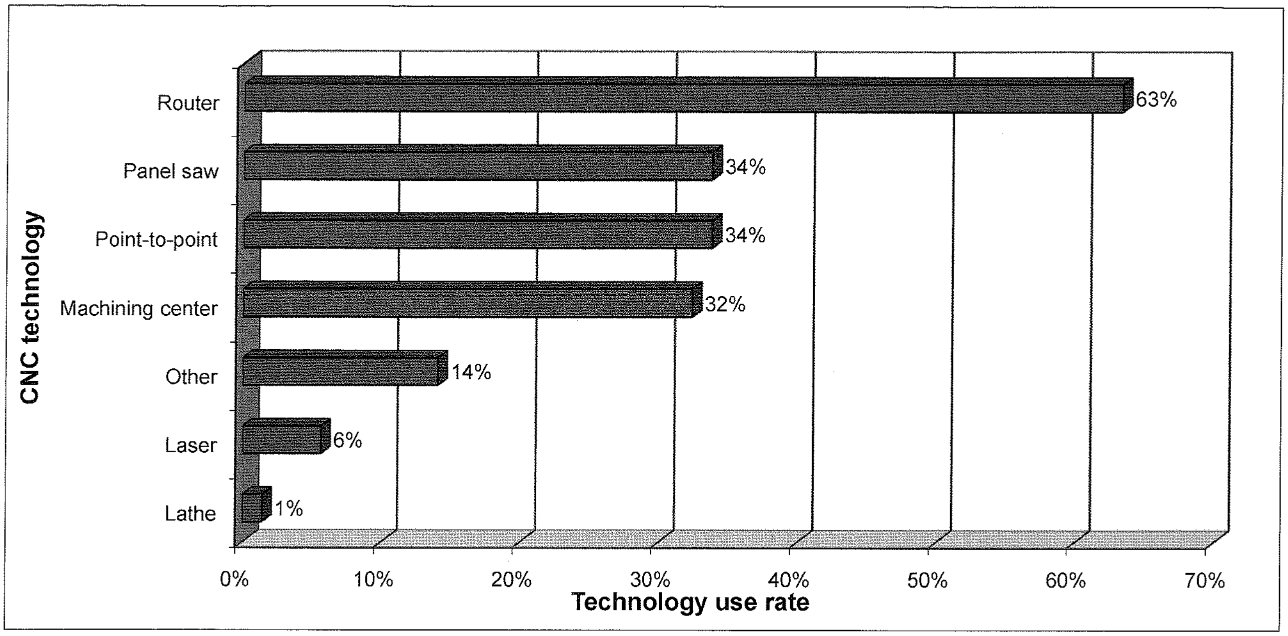

Figure 3.—Types of CNC equipment used by responding companies that employ CNC machining (in percent).

companies that were using more types of CNC equipment purchased their first piece of CNC equipment earlier than did companies using fewer types. For those companies currently using only one type of CNC machinery, the average date of acquisition was 1999. For those companies currently using two, three, four, and five types of CNC machinery, the average dates of acquisition of their very first CNC machine were 1996, 1993, 1988, and 1987, respectively. It appears that the cycle for adoption of new CNC technologies is approximately 3 to 5 years for companies using more than one type of CNC machinery.

Respondents from companies that used CNC technologies indicated their level of agreement with 11 statements about CNC implementation. The average (mean) Likert scale agreement rating for each statement is shown in Figure 4 with the statement that met with the strongest agreement given at the top of the list and the statement that received the weakest agreement rating listed at the bottom. These averages were based on responses from 68 adopters of

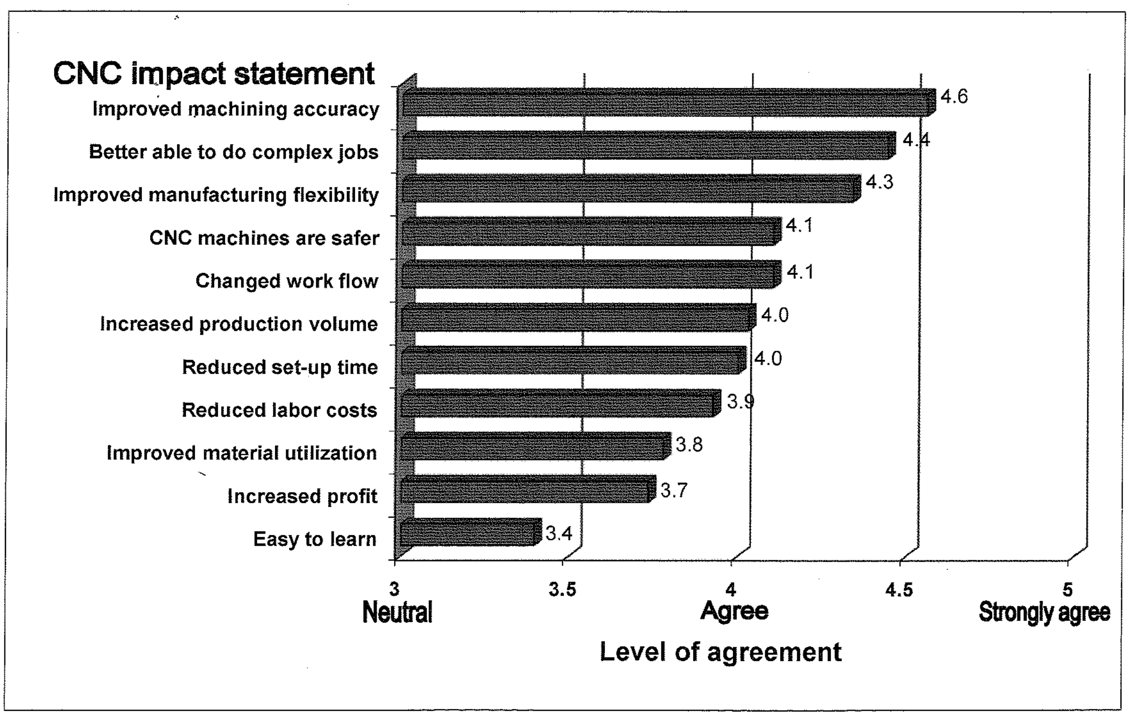

Figure 4.—Five-point Likert scale–based agreement ratings for statements concerning CNC implementation—mean results based on 68 responses.

Table 4.—Level of agreement with 11 statements related to CNC technology use for wood products firms in different sectors and of different sizes.[a]

MANOVA variable	P value (Wilks' λ)			
Firm size	0.10			
Product type	0.81			
Firm size × product type interaction	0.37			
	ANOVA and LSMEANS for firm size			
	P value	Large	Medium	Small
Easier to learn	0.71	3.38	3.55	3.19
Increased profit	0.88	3.67	3.76	3.88
Safer to operate[b]	0.06	3.72 A	4.33 B	4.05 AB
Improved material utilization	0.69	3.81	3.85	3.57
Improved machining accuracy[b]	0.04	4.40 A	4.84 B	4.32 A
Improved ability to perform complex jobs	0.17	4.41	4.73	4.23
Improved flexibility[b]	0.08	4.18 A	4.67 B	4.17 AB
Reduced labor costs	0.72	3.90	4.18	4.02
Reduced set-up/ changeover time[b]	0.07	4.13 AB	4.35 B	3.40 A
Increased production volume	0.79	3.97	4.14	4.12
Changed work flow	0.58	3.94	4.21	4.18

[a] Rating scale ranged from 1 = strongly disagree to 5 = strongly agree.
[b] Group means with the same letter are not statistically different based on the Tukey studentized range test separation of means procedure (P = 0.10).

CNC machining technologies. The three statements that received the strongest endorsement were (1) Adopting CNC machining technology . . . improved our machining accuracy (mean = 4.6, median = 5.0), (2) . . . improved our ability to perform complex jobs (mean = 4.4, median = 4.5), and (3) . . . improved our manufacturing flexibility (mean = 4.3, median = 4.0). The statement that received the weakest level of support was new CNC equipment is easy to learn to operate and program (mean = 3.4, median = 4.0).

MANOVA results indicated that statistical differences were marginally evident among firm sizes ($P = 0.10$) but absent among product types ($P = 0.81$; Table 4). Firm size–based differences in attitudes toward CNC equipment were detected for the statements CNC machines are safer to operate than non-CNC machines, Adopting CNC machining technology has improved our machining accuracy, Adopting CNC machining technology has improved our manufacturing flexibility, and Adopting CNC machining technology has reduced our set-up/changeover time. For each of these statements, respondents from medium-sized firms expressed stronger agreement than did respondents from large and small firms (Table 4).

CAD adoption

The three statements that targeted users of digital design and drawing software (CAD) each met with, on average, low-level agreement based on 113 responses: (1) Using CAD software has reduced the length of time required for product design, rated a mean score of 3.9, (2) Using CAD software has allowed us to produce more complex products, rated a mean score of 3.8, and (3) Using CAD software has reduced our labor costs in the design phase, also rated a mean score of 3.8—just less than the 4.0 level that indicates agreement with the statement. Together with the ratings obtained for the statements that addressed the expectations and benefits of using CNC equipment (Fig. 3), the mean scores recorded for these statements on the use of CAD address Objective 3.

MANOVA results indicated that statistical differences were absent in the level of respondent agreement with each of these three statements—neither product type ($P = 0.77$) nor firm size ($P = 0.44$) nor the interaction of these two main effects ($P = 0.98$) affected the rating given to these statements by respondents.

Seventy percent of the 113 companies that indicated they used CAD were using it to perform two or more tasks. The most common use of CAD was in developing detailed product renderings (67% of companies using CAD used it for this), but CAD was used almost as frequently in preliminary concept development (61% of users), and only slightly less frequently for CNC equipment control (49% of users).

Summary and Conclusions

A mail survey was sent to 1,500 value-added wood products firms in the northeastern and north-central United States in the fall of 2006. The two-page survey was designed to collect information on the usage and impacts of digital technologies in the design, production, and marketing of wood furniture, cabinets, and architectural woodwork. An 11.6 percent response rate (174 usable surveys) was obtained from a single mailing. Seventy-seven percent of responding firms used one or more types of digital technologies in their operations. These firms used, on average, 2.8 different types of digital technologies with CAD, CNC, and Web sites reported to be the most widely adopted technologies.

Firms having 50 or more employees reported having adopted, on average, 4.3 types of digital technologies in their operations. Mid-size firms reported adopting an average of 3.0 types of technology. Small firms had adopted 1.3 types of digital technologies in their plants. This firm size–based difference in the rate of technology adoption was statistically significant. Differences in adoption rates based on the type of product produced by a firm were not significant.

Firms that experienced revenue growth during the period 2001 through 2006 had adopted either a few (one to three) or several (four or more) types of digital technologies, whereas firms that had not adopted any digital technologies were more likely to have experienced either stagnant or declining revenue (Table 3).

Despite the fact that Web sites were one of the most widely adopted digital technologies, only 9 percent of responding firms reported using Web sites for product sales. Web-based sales comprised, on average, 12 percent of total product sales for these firms.

Of the 71 responding companies that used CNC machines in their wood products manufacturing operations, 63 percent were using one or more CNC routers. From a list of 11 statements related to CNC implementation, the three statements that received the strongest support by firms that have adopted CNC technologies were (1) Adopting CNC machining technology . . . improved our machining accuracy, (2) . . . improved our ability to perform complex jobs, and (3) . . . improved our manufacturing flexibility. The statement that received the weakest level of support based on opinions expressed using a 5-point Likert scale was New CNC equipment is easy to learn to operate and program. However, even this lowest-rated CNC attribute received a mean score of 3.4 indicating low-level agreement with the statement. Statistically significant differences in how respondents from small, medium, and large firms rated these CNC statements were detected for four of the statements (Table 4).

CAD was used by 65 percent of responding firms with the most common use being for developing detailed product renderings. CAD was used almost as frequently in preliminary concept development, and only slightly less frequently for CNC equipment control. The three statements concerning CAD implementation that were ranked by respondents all met with a moderate level of agreement: (1) Using CAD software has reduced the length of time required for product design, (2) Using CAD software has allowed us to produce more complex products, and (3) Using CAD software has reduced our labor costs in the design phase. No firm size– or sector-based differences in the ratings given to these statements were detected.

The use of digital technologies by value-added wood products manufacturers in the eastern United States was recognized by many companies to be an important component for competitive success. Approximately three-quarters of these firms used one or more types of digital technologies with CAD, CNC, and Web sites found to be the most common. An oft-cited benefit of digital technologies was the increased ability to develop complex products. Large and mid-size firms were more likely to have adopted digital technologies than small firms. There was a significant relationship between digital technology use and wood products revenue enhancement though the nature of the relationship was not elucidated in this study.

Digital technologies, while more broadly adopted by larger firms, can be found in furniture, cabinet, and architectural millwork manufacturing facilities of all sizes. These technologies provide a wide range of benefits to the firm. While capital investments in new equipment slow during recessionary periods, the pattern of digital technology adoption by wood products manufacturers indicates a high probability that companies with CAD and CNC technology experience will adopt additional digital capabilities when markets strengthen.

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